CLAVIER Newsletter

June 2008, Issue 3

"Climate Change and Variability: Impact on Central and Eastern Europe"

Contents:

CLAVIER progress since September 2007- a brief summary of the workpackages

WP1: Climate Change Simulations and assessment of uncertainties

Both REMO and LMDZ models have finalised to run their validation simulations, nested into the ERA40 dataset. Comparison with observations is underway with different common or specific diagnostics. Some interesting diagnostics ideas were suggested to understand the Summer Drying Problem (SDP) which seems persistent in the newest version of REMO model. See more details of the evaluation and validation of REMO under the "RCM Workshop in Hamburg" in separate article later in this Newsletter.

WP2: Optimized input data for climate impact studies from RCMs

Statistical downscaling and error correction methods for daily precipitation and mean/maximum/minimum 2 m temperature have been set up and tested in the Alpine region. The evaluation for precipitation is finished and shows very promising results, the evaluation for temperature is currently performed. The most effective methods are currently (precipitation) or shortly (temperature) applied to the REMO59-ERA40 and REMO59-A1B (25 km grid spacing) simulations of WP1 to provide value added products for climate change impact studies on one hand, and to be later compared to high resolution dynamical downscaling (10 km grid spacing, REMO59-ER40-high and REMO59-A1B-high) on the other hand. Three different versions of the downscaled/error corrected climate scenario are under preparation:

- STATCLIMATE-ECA (0.25° gridded error corrected scenario for the entire CLAVIER region, based on the gridded ECA dataset (http://eca.knmi.nl/download/ensembles/ensembles.php),
- STATCLIMATE-HUN (0.1° gridded scenario for Hungary, based on the HUN-grid dataset provided by OMSZ),
- STATCLIMATE-STATION ("station scale" climate scenario for selected sites as needed by the CLAVIER climate impact case studies).

A multi-linear regression model of crop yield with objective automated predictor screening has also been set up and crop yield data from the Romanian and Bulgarian study regions has been collected.

WP3a: Impact on Weather Regimes

The following tasks started, and some of them have already been completed:

- Homogenization of the Hungarian daily observational data (MASH: Multiple Analysis of Series for Homogenization software and its application);
- Interpolation of daily observational data for a grid over Hungary (MISH: Meteorological Interpolation based on Surface Homogenized Data Basis and its application);
- Pre-processing of ERA40 re-analysis data for their use in the synoptic scale synoptic-climatological studies;
- Hemispheric and regional synoptic-climatological studies (investigation of weather patterns).

During the last half year, the main emphasis was put on the final development of the MISH interpolation system, which is a software, capable to interpolate observational data onto a regular latitude-longitude grid. The interpolation based on MISH is used to create gridded dataset for Hungary. Beside the interpolation activities work had been started to prepare the synoptic-climatological studies based on model data. It was decided that the ECHAM (lateral boundary) data have been used for these studies for the periods 1961-2000 (as it was the case for the ERA40 evaluations) and 2010-2050 respectively.

WP3b: Impact on extreme events

WP 3b started its work with deriving indices for extreme events from the finalized 25km REMO simulations, both for the ERA40 driven simulation and for the control period (1951 to 2050) of the A1B simulation. The indices have been defined in WP2 and are based on the STARDEX definitions and on specific requirements of the CLAVIER partners. In total, 24 indices for extremes are considered, mainly based on temperature, precipitation and wind speed. Identical parameters will (where possible) be derived from observational datasets. A comparison of model-based and observation-based extreme indices will be carried out to assess the ability of the models to reproduce present-day extreme events. The work has started using the gridded observational dataset for Hungary (WP3a), which was provided for CLAVIER studies by the Hungarian Meteorological Service and the gridded observational dataset compiled in the framework of the ENSEMBLES project. The indices have also been derived for the future climate period of A1B scenario simulation (2001 to 2050) to assess the impact of climate change on extreme events.

WP3c: Impact on hydrological and agricultural regimes

WP 3c efforts covered mainly the following items in the last half year:

- Preparation and updating of current hydrological climate description for the Tisza, Mures Basin and the Arges Basin;
- Development and application of extreme value analyses tools for flood series for selected stations within the three study catchment area. The given tools include analysis of annual maxima series (AM) with fitting General Extreme Value (GEV) distribution and Peak Over Threshold (POT) series with fitting Generalised Pareto Distribution (GPD). Both AM-GEV and POT-GPD models are applied for the whole observed series and in time-dependent mode. The given tools are foreseen also to analyse future climate simulation results.

VITUKI hydrological modelling system was re-calibrated and run for the Tisza Basin using ERA40 input data sets together with PRUDENCE and ETH simulations. Smoothing of hydrological input fields has been observed and attempts are made to represent natural spatial variability in synthetic series. Preliminary results will be utilized as feedback for WP2 statistical downscaling. Lake evaporation simulations were validated using ERA40 and HUNGRID data sets for Lake Balaton with special emphasis on Keszthely Bay (see separate article). A part of WP3c is engaged in analysis of water stress and its impact on agricultural regimes. The studies are focused on NW of Romania and NE of Bulgaria. The spatial algorithms for calculating water stress are embedded in the established GIS. Water stress is quantified by the relation of potential and actual evapotranspiration. The calculation of potential evapotranspiration (ET0) is based on two equations: Hargreaves and FAO Penman-Monteith, which were tested and compared. The FAO equation is a physically based approach and needs a lot of input data but provides best results. This formula will be used because of the prospected availability of all essential input data from regionalised climate models provided by WP1. As an ongoing activity spatial interpolation of ET0 will be optimised by consideration of a radiation model which includes the variability of topography (aspect, slope, elevation).

WP3d: Impact on natural ecosystems, human health and infrastructure

Although this workpackage just started in March 2008, a comprehensive literature review and data collection have been made for the selected case studies (CS) of Roads (CS-1), Ecosystems of Hortobágy (CS-2), Common Ragweed (CS-3) and Heat Waves (CS-4). The following processes have been already started:

- Selection of the high allowed axle weight roads in Hungary (CS-1)
- Identification of study area and selection of the indicator species in the Hortobágy area (CS-2)
- Identification of study area (Szeged) and preliminary methodological development (CS-3)
- Options to simulate the urban heat island effects (CS-4)

WP4: Economic vulnerability of CEE Societies and economic impact assessment

At the moment a cluster analysis is conducted with different indicators related to socio-economic adaptive capacity for the CLAVIER region on a NUTSII level. Related to the sectoral case studies, the following progresses have recently been made:

- Agricultural case studies: the databases are ready and are now being used by Wegener Center for regression analysis
- Tourism case studies: the data bases are ready
- Energy case studies: still some open questions regarding data availability especially real data concerning past energy production, energy supply etc.

We also started with a literature survey and data and information collection on the institutional settings regarding financial risk transfer and management and have already completed a draft of the public sector case study of Romania which will also serve as a model for the other two case studies.

RCM Modelling Workshop in Hamburg

At the end of November, 2007 a one-day workshop was set up as part of the workpackage WP1 "Climate change simulations and assessment of uncertainties" and held in the Max Planck Institute of Meteorology in Hamburg (Germany). The main issue of this workshop focused on validation of the regional climate models (REMO and LMDZ) used in the CLAVIER Project with special emphasis on the Summer Drying Problem (SDP), which is a general bias of the regional climate models for the region of the Danube catchment. The experts of MPI-M, CNRS and HMS were taking part on this important event of WP1. First, the results achieved by the REMO and LMDZ

Hamburg from bird's eye view

models were assessed and it was realized that SDP is present only on the REMO simulations.

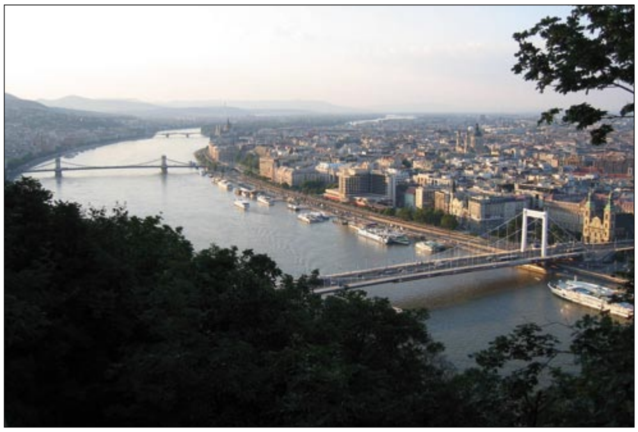
The ensuing discussion was concentrating on the possible further diagnosis of this problematic together with the possible solutions for its elimination. The following ideas were assessed:

- Sensitivity to the domain size with special emphasis on the moisture transport through the lateral boundaries of the model.
- The diagnosis of vertical motions together with its inter-relation to the dynamics of the model.
- Diagnosis of the weather patterns simulated by the REMO model.
- Control of the soil moisture capacity arising from the physiographic description of the soil characteristics.
- Check of the energy balance with emphasis of moisture, water vapor and evaporation transport through the boundaries of the model.

These issues were discussed in details and the share of work between the project partners of WP1 was proposed and accepted. It was added that the validation issues of the regional climate models should be addressed in a larger context together with the CECILIA project's researchers (this was further discussed in the RCM mini-workshop organized in Budapest at the beginning of February, see below).

Max-Planck-Institut für Meteorologie
Max Planck Institute for Meteorology

RCM Workshop - cooperation with CECILIA



Budapest from bird's eye view

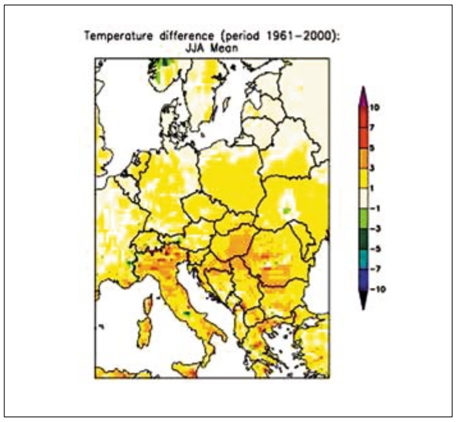
Headquarters of Hungarian Meteorological Service

Regional Climate Modelling Mini Workshop (which was "mini" regarding its duration, but not as regards the number of participants) was organized at the Hungarian Meteorological Service in Budapest between 4-6 February, 2008. The date of the workshop was chosen considering the fact, that the CECILIA annual meeting (also in Budapest) was planned to be organised around the same period. Therefore the meeting served also as an excellent opportunity to organize a round-table discussion on the current status of regional climate models (RCM) with special emphasis on those applied in the CLAVIER and CECILIA projects and to strengthen the scientific cooperation between the two EU FP6 projects. After the introductory talks about the large international and European cooperations the programme focused on the general and practical issues related to regional climate modelling.

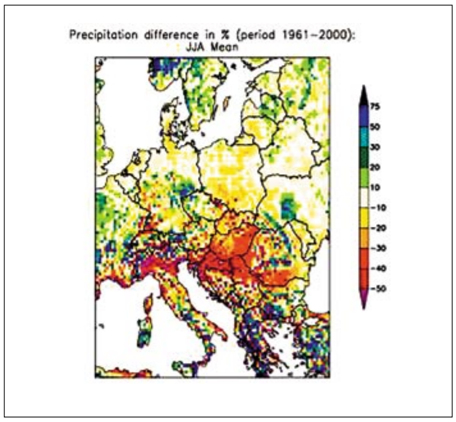
Regarding the model validation several results were presented about the state-of-the-art models used by the CECILIA and CLAVIER partners, and their conclusions indicate towards the necessity of a common evaluation strategy between the model validation groups of the two projects. Basic issues were discussed in the session for extreme events, e.g.: Should a "list of indices" be used depending on the region of interest or should common indices be applied for all case studies? Regarding the application of RCM outputs on the one hand interesting results were presented about the essential role of the ocean and the air quality in regional changes, on the other hand the session served useful information about the WATCH project and the National Climate Change Strategy in Hungary. As far as the concrete cooperation between the two projects is concerned, the necessity of establishment of a CLAVIER and CECILIA (process-oriented) model validation working group was

Validation of the CLAVIER models for the present climate

In the CLAVIER project, three different regional climate models are used to form a small model ensemble: two versions of the REMO model (REMO5.0 operated at the Hungarian Meteorological Service, REMO5.7 developed at the Max-Planck Institute for Meteorology in Hamburg) and the LMDZ model from CNRS in Paris. With each of these models, two experiments were carried out: the first one being a simulation of a past period from 1961 to 2000, driven and initialized by the ECMWF ERA40 reanalysis data, the second one being a long transient simulation for the hundred years of 1951 to 2050, driven by an A1B scenario simulation of the global coupled atmosphere-ocean model ECHAM5. With LMDZ, an additional A1B simulation driven by data from the global IPSL model has been performed. The integration domain and the model resolution were comparable for all models and simulations, covering large parts of Europe with a horizontal resolution of between 25 and 30 km.



Difference of the summer mean (2m) temperature (in Celsius degree) between the model results and the CRU dataset for the period of 1961–2000. The REMO 5.7 experiment was driven by the ERA40 reanalyses



Relative difference of the summer mean precipitation (in percentage) between the model results and the CRU dataset for the period of 1961–2000. The REMO 5.7 experiment was driven by the ERA40 reanalyses

It is very important to analyse the model results for today's climate conditions, this means to compare the results for the ERA40 driven runs and the control climate (1951 to 2000) from the transient runs against observations. This will provide the baseline information about the model quality and offers the possibility to judge on the reasonability of the climate change signals.

Investigating the results of the **ERA40 driven simulations** it could be generally concluded, that the two REMO versions clearly overestimate the temperature and underestimate the precipitation in summer and autumn seasons over the Carpathian Basin (see figures for REMO5.7). At the same time the precipitation is overestimated in the winter and mostly in the spring months for the REMO5.0 simulation, resulting in a relatively good overall annual performance for the precipitation field. The overestimation of summer temperatures in the CLAVIER target region is much less pronounced in the LMDZ simulations, whereas the summer precipitation is overestimated for the LMDZ ERA40 simulation.

Regarding **the long transient simulation** the outcomes are evaluated for the time being only for the past period of 1961–1990 with respect to observations and also with the "reference" results of the ERA40 experiment. The primary goal for the latter inter-comparison was to better understand the impact of the lateral weather conditions for the models: whether "perfect" boundary conditions provide more realistic estimations or simulated, but possibly more consistent ones (since the ECHAM5 boundary conditions are in good physical consistency at least with the REMO model's internal dynamics and physics) provide better results compared to the observations.

Temperature: while the REMO simulations driven by reanalyses overestimate the summer temperature almost over the entire domain, in the case of the ECHAM5 experiment the errors are significantly reduced. In comparison to the gridded observational dataset (HunGrid) provided by the Hungarian Meteorological Service, the summer temperatures over Hungary show only a slight overestimation of about 1°C for the REMO5.7-ECHAM5 simulation, a slight warm bias is also visible for the winter temperatures (not shown). It is remarkable that the REMO5.0-ECHAM5 run provides basically no annual temperature bias and at every season significantly outperforms the REMO5.0-ERA40-driven integration (see table). For LMDZ, the ECHAM5 driven simulation agrees well to observed temperatures, the LMDZ-IPSL simulation is by about 2°C cooler.

Precipitation: For the REMO5.7-ECHAM5 simulation, the underestimation of summer precipitation which showed up in the REMO5.7-ERA40 simulations is significantly reduced. However, a smaller overestimation of winter and early spring precipitation compared to the HunGrid data can be observed, resulting in a flattening of the annual cycle of precipitation for

	Mean (2m) temperature [°C]					Precipitation [mm/month]				
	Annual	MAM	JJA	SON	DJF	Annual	MAM	JJA	SON	DJF
REMO(ERA40) – CRU	2.0	1.45	3.41	2.49	0.35	-1.17	5.71	-5.67	-8.00	3.19
REMO(ECHAM) – CRU	-0.01	-0,43	-0.05	-0.11	0.26	7.68	16.81	-1.94	7.50	8.07

The annual and seasonal differences between the different REMO 5.0 simulations and the CRU dataset averaged for Hungary. The values are valid for the period of 1961–1990

Hungary. In the case of the REMO5.0-ECHAM5 simulation it can be concluded that the “ERA40-driven” underestimation of the mean precipitation over the Carpathian Basin changed to overestimation and generally speaking it can be said that the ECHAM5-driven run performs clearly better during the summer, its bias is similar for autumn and meaningfully worse for spring and winter (see table). For LMDZ, the overestimation of summer precipitation in the ERA40 driven simulation is reduced, resulting in underestimated summer precipitation values for the LMDZ-ECHAM5 simulation.

As a general conclusion it can be said that in spite of the fact that the ERA40 data are considered to be “perfect” boundaries, for the REMO models the ECHAM5 physically consistent lateral boundary conditions provide better results than it is the case for the ERA40-driven case. LMDZ does not significantly perform better with ECHAM5 driving data compared to the ERA40 driving data

Comparing evaporation estimates for Lake Balaton in Hungary using REMO data and surface measurements

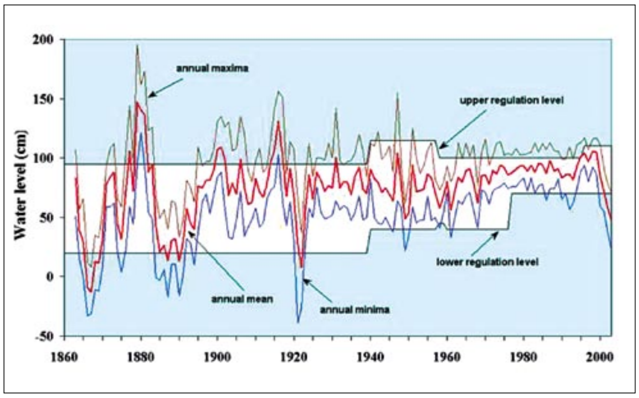


Fig. 1. Changes of water levels and regulation thresholds for Lake Balaton

Water balance of the Lake presents great interest due to the fact that water levels change within wide ranges (Fig. 1). Key element of the water budget is lake surface evaporation is analysed on a detailed way within the CLAVIER Project. Morton’s WREVAP model (1985) of areal and lake evaporation has been tested for Lake Balaton in Hungary with the 25-km resolution REMO simulation (driven by the ERA40 re-analyses) data for 1960–2000, provided by the Hungarian Meteorological Service (HMS) and with surface measurements of air temperature, dew point temperature (or relative humidity), and global incoming radiation supplied also by HMS and by various water resources organizations of Hungary. The resulting lake evaporation estimates are on a monthly basis. Static input parameters comprise of the elevation of the lake, latitude of the meteorological station (or REMO cell) that provides the climate values, the mean depth of the lake, and the average salinity of the lake water.

We were interested in testing how the ‘summer warming’ effect, i.e., elevated modeled air temperatures and drier air, of the REMO data affect the estimated evaporation rates. The comparisons were aided by water balance closure values for the lake, calculated by VITUKI. Surface measurements were available for two periods: (1) 1966 – 1992, and; (2) 1997 – 2000. For these time intervals most of the data came from the meteorological station at Keszthely, some variables were provided by the surface observation station at Siófok. Stations are located consequently at the north-western part of the lake’s basin and on the southern shore. For the first period mean annual lake evaporation became 837 mm with surface measurements and 860 mm with REMO data, while water balance closure yielded 871 mm (Fig. 2). For the second, much shorter period, the same values are: 867 mm, 926 mm, and 926 mm, respectively. As Fig. 2 demonstrates, lake evaporation had an overall declining trend between 1966 and 1980, while it expressed an opposite tendency since 1981. The WREVAP model estimates too, follow these trends.

Overall it can be stated that the model is not too sensitive to the slight-to-moderate error in the REMO simulation data concerning spurious elevated air temperatures and diminished air humidity in the summer months. Therefore the REMO data seem to be adequate to represent the past in terms of lake evaporation estimates, and thus it is also expected that it will be reliable in future climate scenario analysis of the same purpose.

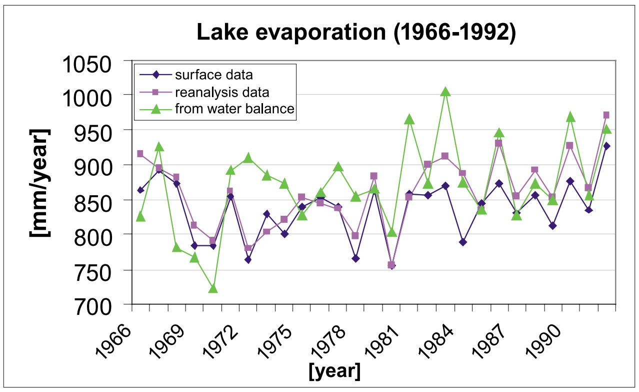


Fig. 2. Estimated annual evaporation rates for Lake Balaton.

Overview of the National Climate Change Strategy - Hungary

Logo of Hungarian National Climate Change Strategy

On March 17th, the Hungarian Parliament unanimously accepted the National Climate Change Strategy, a 114-page document about climate policy guidelines in Hungary through 2025. The strategy was accepted with the agreement of all the Members of the Parliament. The problem of climate change is extremely important for Hungary because, as the document points out, global warming will affect the Carpathian Basin to a greater extent. Each increase of 1 degree Celsius in the world's average temperature means an increase of 1.5-2 degrees Celsius in Hungary, holding the potential for devastating effects to biological diversity. The Strategy concentrates on the following priorities

- Reduction of GHG emissions in order to mitigate the effects of climate change. Starting energy-saving programmes, improving energy efficiency, reducing the use of fossil energy sources, increasing the share of renewables.
- Adaptation to the effects of climate change. The main difficulty is that extreme weather phenomena and changing patterns can appear at different times and in different ways in given geographic areas. Important steps are to be taken in the fields of water management, agriculture, forestry and healthcare.
- The third or additional aspect within the Strategy is raising public awareness.

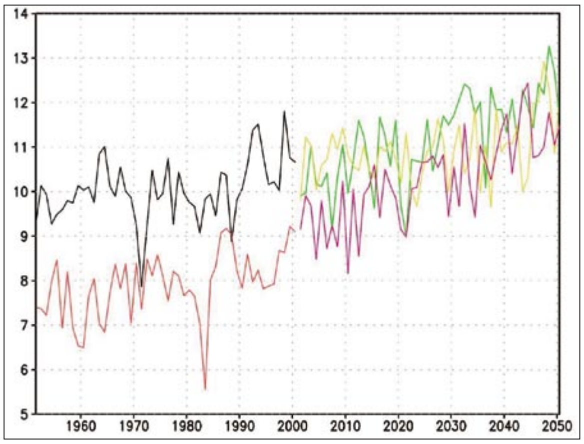
The strategy includes both the possibilities of slowing global warming and the potential ways we can adapt to the inevitable changes. Hungary is responsible for only 0.05% of the world's greenhouse gas emission, and the strategy stresses the importance of reducing it further. The rate of using renewable energy sources would be increased to 13 percent from the current 4.5 percent. The energy sector would play a critical role in the reduction of the greenhouse effect because it is responsible for 75% of greenhouse gas emissions.

The document defines the tasks necessary in order to adapt to unavoidable climate changes. The changes will affect the human healthcare sector, agriculture, water economics and environmental protection. The sooner society and the government realize the urgent need to prepare for these events, the lower the costs will be. The new strategy was preceded by a three-year research project called VAHAVA, (Change-Impact-Response), co-conducted by the Hungarian Academy of Sciences and the Hungarian Ministry of Environment and Water dealing with the impacts of the climate change. The meteorological-climatological background of the climate change was provided by the Hungarian Meteorological Service and the Eotvos Lorand University with the evaluation of the PRUDENCE results over Hungary. The Strategy was also preceded by considerable expert work by government, scientific and civil bodies. The government will follow up on the strategy by regular reviews. They will also adapt the National Climate Change Program, which is a detailed action plan for two years.

The implementation of the Strategy claims a huge amount of financial resources. In the frame of the Environment and Energy Operational Programme 110 billion HUF will be available for developing of energy efficiency and consumption of renewable energy investments between 2008 and 2013. The Hungarian Government plans to implement the Green Investment Schema (GIS), which is one of the flexible mechanisms of the Kyoto Protocol. GIS could provide about a few billion HUF annually for climate protection investments. In addition, incomes from the EU Emission Trading Scheme may be added with the approximate amount of 3.3-3.7 billion HUF annually. Principally, these resources could finance the increase of the energy efficiency of both the existing and the planned buildings in the private and the public sector.

Hungarian Parliament

Climate change scenario runs with LMDZ-regional



LMDZ simulation for the CLAVIER region: annual mean temperature

The LMDZ-regional climate model being validated against the observed climatology in previous works, now CNRS/IPSL is strongly involved in the production of climate change scenarios for the CLAVIER domain. The model is forced through its lateral boundary conditions coming from the global scenarios produced in both MPI in Hamburg using ECHAM5 (MPI-GCM) and IPSL in Paris using IPSL-GCM. Within CLAVIER it has been decided to concentrate on the A1B scenario for all activites. However, it is important to relate the possible changes associated with A1B to other climate change scenarios. Therefore, we take into account both A1B and B1 emission scenarios in this study. The enclosed Figure plots the temporal evolution of annual-mean surface air temperature, averaged for the CLAVIER domain. The black curve indicates the 20th-century LMDZ-ECHAM5 simulation for the period 1951-2000. The counterpart from LMDZ-IPSL is represented in orange curve. A short comparison against observed climate is presented in the article about the "Validation of the CLAVIER models for the present climate" in this Newsletter.We can observe a general warming trend for the last two decades of the 20th century for the two curves, but the LMDZ-IPSL result is about 2°C cooler than the LMDZ-ECHAM5 result. The green and yellow curves (from 2001 to 2050) are the A1B and B1 scenarios from LMDZ-ECHAM5, respectively. The A1B scenario is generally warmer than the B1 scenario, but the difference is small for our considered time scale, around 2050. The red curve is the A1B scenario from LMDZ-IPSL for the period 2001-2050 (the B1 scenario from LMDZ-IPSL is underway and will be reported later). Despite the general cool feature of LMDZ-IPSL in the 20th century, the future warming is much important, the surface air temperature reaches a very similar level as in LMDZ-ECHAM5. This indicates that the temperature increase is about 2°C larger in LMDZ-IPSL than in LMDZ-ECHAM5, which is directly related to a different behaviour of simulated climate sensitivity in the two IPCC-AR4 models developed and used in Hamburg and Paris respectively. Such a result seems to confirm our initial intuitive expectation that important uncertainty still remains among different global ocean-atmosphere coupled models used for future projection of global climate evolution. Currently, the analyses of uncertainties related to regional models are underway through the comparison between LMDZ and REMO models. How to explore the uncertainty issue in climate change prediction and how to use the uncertainty consideration into impact studies will constitute a main challenge for our future works.

Cooperation with ENSEMBLES project

CLAVIER is affiliated partner of the ENSEMBLES project - very large project funded by EU. ENSEMBLES aims at the prediction of both natural climate variability and the human impact on climate, which is inherently probabilistic, due to uncertainties in forecast initial conditions, representation of key processes within models, and climatic forcing factors. Hence, reliable estimates of climatic risk can only be made through ensemble integrations of Earth-System Models in which these uncertainties are explicitly incorporated. For the first time, a common ensemble climate forecast system will be developed for use across a range of timescales (seasonal, decadal and longer) and spatial scales (global, regional and local). For more details, please visit the ENSEMBLES web page: www.ensembles-eu.org

Project partners:

Max-Planck-Institut für Meteorologie
Max Planck Institute for Meteorology

Coordinator: Max Planck Institute for Meteorology (MPI-M), Hamburg, Germany
Homepage: www.mpimet.mpg.de/en/home.html
Contact persons:
Daniela Jacob daniela.jacob@zmaw.de
Susanne Pfeifer susanne.pfeifer@zmaw.de

Hungarian Meteorological Service (OMSZ)
Budapest, Hungary (co-coordinator)
Homepage: www.met.hu/omsz.php

András Horányi horanyi.a@met.hu
Gabriella Szépszó szepszo.g@met.hu

Laboratoire de Meteorologie Dynamique (LMD), Institut Pierre Simon Laplace (IPSL), Centre National de la Recherche Scientifique (CNRS), Paris, France
Homepage: www.lmd.jussieu.fr/en

Laurent Li li@lmd.jussieu.fr

VITUKI Environmental Protection and Water Management Research Institute (VITUKI), Budapest, Hungary
Homepage: www.vituki.hu

Gábor Bálint balint@vituki.hu

Env-in-Cent Consulting Ltd. (EiC), Budapest, Hungary
Homepage: www.env-in-cent.hu

Tamás Pálvölgyi tpalvolgyi@mail.datanet.hu

University of National and World Economy (UNWE), Sofia, Bulgaria
Homepage: www.unwe.acad.bg

Plamen Mishev mishevp@intech.bg

Babes-Bolyai University (UBB), Cluj, Romania
Homepage: www.ubbcluj.ro

Mária Vincze mvincze@econ.ubbcluj.ro

Wegener Center for Climate and Global Change (WegCenter), University of Graz, Austria
Homepage: www.wegcenter.at

Andreas Gobiet
andreas.gobiet@uni-graz.at

Institute of Technology and Regional Policy (InTeReg), JOANNEUM RESEARCH Forschungsgesellschaft mbH, Graz, Austria
Homepage: www.joanneum.at

Franz Prettenthaler
franz.prettenthaler@joanneum.at

Department of Hydraulic and Water Resources Engineering, Budapest University of Technology and Economics (BUTE), Budapest, Hungary
Homepage: www.bme.hu/en/

József Szilágyi szilagyi@vit.bme.hu

National Institute of Meteorology and Hydrology (NIMH), Sofia, Bulgaria
Homepage: www.meteo.bg

Staytcho Kolev
Stayko.Kolev@meteo.bg

National Institute of Hydrology and Water Management (INHGA), Bucharest, Romania
Homepage: www.inhga.ro

Marius Matreata marius.matreata@hidro.ro

Institute of Geography (IG), Romanian Academy, Bucharest, Romania
Homepage: www.geoinst.ro

Prof. Dan Baltenau geoinst@rnc.ro

Impressum:
Edited by Env-in-Cent Consulting Ltd.
www.clavier-eu.org